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AIRCRAFT OPERATIONS IN CONNECTION WITH STUDIES ON AERIAL SPRAYING, AERIAL SURVEY, AND AERIAL PHOTOGRAPHY
1947 - 48 Seasons

By

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445 U. S. Court House
Portland 5, Oregon
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P R O G R E S S R E P O R T

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SUMMARY

This report summarizes the operation and use of airplanes, principally the N3N-3 airplane (NX 45036), during 1947 and 1948. In 1947 the plane was operated under a cooperative program undertaken by three divisions of the Bureau of Entomology and Plant Quarantine in the Pacific Northwest: Forest Insect Investigations, Truck Crop and Garden Insect Investigations, and Cereal and Forage Insect Investigations. In 1948 operations were confined to forest insect surveys and aerial photography. The detailed findings are being reported separately.

The first phase of work in 1947 was the aerial spraying of peas for the control of the pea aphid (Macrosiphum pisi Kalt.) in the vicinity of Walla Walla, Washington during May, June and July for Truck Crop and Garden Insect Investigations under the supervision of Dr. J. C. Chamberlin. It was necessary to run extensive calibration tests with the poor spraying equipment. A total of 7 strip plots were sprayed on two fields.

The second phase of work, an aerial spray test for control of the vetch bruchid (Bruchus brachialis Fahr.) near McMinnville, Oregon for the Division of Cereal and Forage Insect Investigations was made during the same period under the supervision of L. P. Rockwood. Two strip plots were sprayed on one field.

The third phase, an aerial survey of damage be defoliators in the forests of eastern Oregon and southeastern Washington for the Division of Forest Insect Investigations, was completed in August 1947. Some 7,755,000 acres of forest land were covered in approximately 40 hours of flying time.

The fourth and final phase, aerial photography and aerial strip counts of bark beetle damage on the forest areas of eastern Oregon, was completed in October 1947.

During the 1948 season the N3N-3 was flown 38:55 hours on nine photographic assignments which included experimental forest photography, aerial mapping, low altitude oblique photography, and low altitude photography of aerial spraying activities.

Aerial surveys for the detection of damage by defoliators in the forests of Oregon and Washington during the 1948 season covered 11,042,000 acres in 57:40 flying hours. Local surveys of limited scope were made on the Tongass and Mt. Baker National Forests for the detection of bark beetle outbreaks. Two reconnaissance flights to count bark beetle killed trees were flown on three strips totaling 42 miles on the Warm Springs Indian Reservation.

In connection with the 4,500-acre Hoppner spruce budworm experimental control project a total of 31:30 flying hours was spent in surveying spray areas, checking corner markers, securing critical materials, and indoctrinating the commercial spray pilots with each plot of the project. Radio flight tests were made in cooperation with the Oregon State Board of Forestry Engineering Department to check the performance of their light weight radio equipment. These radios proved invaluable on the Hoppner control project.

INTRODUCTION

During and immediately after World War II the use of airplanes for controlling insects expanded greatly. This development was brought about by several factors, among which were (1) the need to control insect-borne diseases and to protect agricultural crops and forests with a minimum of labor, (2) the development of new and highly effective insecticides, (3) the development of aerial spraying techniques, and (4) the availability of many airplanes and trained pilots. Numerous new problems arose and the Bureau soon became involved in extensive experimentation with aerial equipment, a condition that continues to the present.

Early in 1947 an N3N-3 plane (NX-45036) that had been used by the Division of Insects Affecting Man and Animals for mosquito control at Orlando, Florida, became available for use in the Pacific Northwest. A cooperative arrangement was worked out whereby this plane was to be used by three divisions of the Bureau of Entomology and Plant Quarantine, namely: Forest Insect Investigations, Truck Crop and Garden Insect Investigations, and Cereal and Forage Insect Investigations. The writer was employed in May 1947 and flew the N3N-3 from Orlando, Florida, to Portland, Oregon.

During 1947 the N3N-3 was used cooperatively by the three contributing agencies. The work, while of limited scope, demonstrated the usefulness of airplanes for spraying agricultural crops and for forest insect surveys. It also demonstrated that one plane was not sufficient to carry on both types of work.

Late in 1947 a war surplus N2S-5 Stearman biplane was purchased by Forest Insect Investigations to release the N3N-3 for aerial surveys and photography. The N2S-5 was flown from Augusta, Georgia, to Portland, Oregon, in January 1948 by the writer. This plane was transferred to Truck Crop Insect Investigations at Forest Grove, Oregon, and was converted into a spray plane for use on a Research and Marketing Administration project for control of the pea aphid. In April H. H. Hessig was employed by Truck Crop Insect Investigations to pilot the N2S-5 and to aid in the development of equipment for aerial spraying. The operations of this spray plane in 1948 and the results obtained will be reported upon independently by Dr. J. C. Chamberlin, Truck Crop Insect Investigations, Forest Grove, Oregon.

The present report concerns the operation of the N3N-3 airplane on a three-way basis in 1947 and on forest insect investigations only in 1948. Some incidental observations on the use of other airplanes for forest insect surveys are also included.

AERIAL SPRAYING FOR CONTROL OF TRUCK CROP INSECTS AND CEREAL AND FORAGE INSECTS, 1947

Background

Large-scale commercial spraying and dusting of crops with airplanes in the Northwest to control insects is a development of recent years. Although ground equipment has been taking and continues to take a major role in this region, the airplane has become an important factor in the insect control picture. For detailed reference to use of airplanes in economic entomology see Hawes and Eisenberg 4.

The aerial application of insecticides by conventional airplanes at three feet to ten feet above the vegetation, over steep terrain, and on small fields surrounded by trees and telephone wires is hazardous. Helicopters or ground equipment must perform the control application on such areas. However, the now moderate costs of aerial application by conventional planes on large fields of good terrain offset the costs of ground applications and the damage caused by ground equipment rolling over and through the plants. Large areas can be sprayed or dusted quickly by airplane when time is important with respect to control of the insect involved.

As the use of aircraft for insect control continues to increase, the important question is whether or not aircraft dispensed liquids and dusts control insects as effectively as ground dispensed insecticides. One of the objectives of the 1947 studies by Truck Crop Insect Investigations was to compare the control of the pea aphid (Macrosiphum pisi Kalt.) on field peas by ground and aerial equipment. A similar experiment was conducted by Cereal and Forage Insect Investigations to compare the control of the vetch bruchid (Bruchus brachialis Fahr.) on hairy vetch by aerial spraying and aerial dusting. The following discussion is limited to the operation of the N3N-3 and observations of other commercial spraying and dusting aircraft in the 1947 season.

Aircraft Spray Installation

The N3N-3 which was flown from Orlando, Florida, was equipped with a 35-gallon front cockpit spray tank, multiple nozzle booms, and a ½-inch Oberdorfer direct displacement wind-driven gear pump. This spray equipment had been used satisfactorily for the small volume (one quart to two gallons per acre) required for mosquito control, but was found to be wholly inadequate for truck crop insect control. For pea aphid control an output of 20 to 32 gallons per minute at 70 m.p.h. was required, or an application of four to seven gallons per acre. A second wind-driven ½-inch gear pump was installed to increase output, but the small tubing and restrictions in the spray system made it impossible to obtain the necessary volume. Facilities and time did not permit the installation of more suitable spray equipment during the 1947 pea season. In order to obtain satisfactory tests with existing equipment it was necessary in some cases to re-fly the sample plots for adequate volumes of spray.

Air and Ground Procedures

All aerial spray plots for pea aphid control were located in the vicinity of Walla Walla, Washington. The strip plots were selected in the center of large level pea fields first to decrease as much as possible the hazards of flying three feet to ten feet off the ground, and secondly to permit a safer approach and recovery from each spray run. Each strip plot was 44 feet wide (spray swath width), approximately 1,000 feet long, and was marked at each corner and along the sides by white cards tacked to four foot stakes. An untreated zone about 60 feet wide was left between strips to avoid contamination by cross drifting of the spray. To help guide the pilot during an actual spray run a man was stationed at the center of each end of the plot. Communication between airplane and ground was dependent entirely upon prearranged hand signals.

Aerial applications were flown between dawn and 9 a.m. and between 4 p.m. and sunset when air movement was at a minimum. No tests were made with wind velocities above 6 m.p.h. Flight altitudes above the ground varied from three feet to ten feet. These flight variations were due to small topographic changes and difficulty in judging accurately the distance above ground. In order to improve altitude accuracy and make drift corrections a dry run was flown on each strip plot before spraying. An average airspeed of 75 m.p.h. was maintained on spray runs. This type of flying was exceedingly hazardous and every precaution was taken to avoid accidents. Partial to good control of the pea aphid was obtained in the 7 strip plots sprayed, depending upon the volume of insecticide applied.

The same strip plot method was employed for vetch bruchid control tests in the McMinnville, Oregon, area.

Planes Used in Other Operations

Part of the studies during the 1947 season included the field checking of several commercial dusting and spraying aircraft. Two N2S-5 Stearman spray planes (225 hp. Lycoming) and one N3N-3 duster (450 hp. Pratt and Whitney) were tested for degree of pea aphid control. Although both methods gave partial to good control under different conditions, spray applications appeared to have better distribution and slightly better control than aerial dust applications. Spray and dusting equipment vary from plane to plane; therefore further tests with existing equipment must be made before any conclusions may be drawn.

The test for control of the vetch bruchid by aerial spraying with the N3N-3 showed slightly better than the commercial aerial dusting application flown the same day.

Power Limitations of Biplanes for Crop Dusting

Crop duster pilots operating biplanes at low altitudes in the Southern States find the 220 hp. Lycoming and 235 hp. Wright engines satisfactory to carry the pay loads limited by the C.A.A., but find they

lack sufficient power in an emergency. Those pilots who have installed 300 hp. Lycoming engines in their biplanes agree that performance is much improved over the lower horsepower engines.

For safe operation from 2500 feet up to 3500 feet above sea level pilots have sometimes had to reduce their load by as much as 40% when using 220 hp. or 235 hp. engines. The 300 hp. Lycoming engines are satisfactory for higher elevation dusting and spraying but are underpowered for emergencies with a full load.

Biplanes equipped with 450 hp. Pratt and Whitney engines and two position propellor are able to carry the largest pay load at any altitude and have the additional horsepower to meet nearly any flight conditions. However, there are three disadvantages in the use of this engine in biplanes: (1) forward visibility is decreased by the larger engine and vertical exhaust stack, (2) operational costs of gas and oil are nearly doubled over that of the 300 hp. or 220 hp. engines, and (3) the glide angle of the biplane is poor in case of engine failure due to the added weight of the larger engine, and extra gas and oil required.

Recommendations

From observations and discussions with pilots and crop dusters in California, Oregon, Washington and the Southern States the concensus is that there is a definite need for a new type of spray and duster airplane which has the following features: (1) highest degree of maneuverability at low speed, (2) unimpaired forward visibility, (3) sufficient horsepower to carry a big pay load of dust or spray easily and to have reserve horsepower to meet any flying emergencies caused by high altitude, short or rough runways, and by turbulent air or downdrafts, and (4) low maintenance and operational costs. (See Walker 6, Miller and Heller 5).

The most desirable plane would be a four or five-place high-wing monoplane structurally suited for attaching spraying or dusting equipment and capable of meeting the above requirements. As yet no aircraft has been designed or manufactured specifically for crop dusting. Prewar biplanes are used to a greater extent for commercial crop dusting and spraying than any other because of good air performance with large loads at low speeds, low operational costs, and low purchase price. Two-place monoplanes can be equipped with dusting equipment but pay loads are small.

Since biplanes will continue to be used for spraying and dusting in all regions it is recommended that 300 hp. or 450 hp. engines be installed to provide a greater margin of safety and to improve operational performance with large loads. The development of good aerial spraying and dusting equipment is essential to uniform distribution of insecticides and maximum control of insects.

AERIAL SURVEYS - GENERAL CONSIDERATIONS

It has long been recognized that aerial surveys hold great promise in the detection and evaluation of forest insect outbreaks. Large areas of forested land can be covered rapidly and economically with airplanes. The main problems are to develop fully reliable aerial survey techniques and to work out an integrated program of aerial and ground surveys.

In the West aerial surveys for the detection of forest insect outbreaks were first investigated in 1925 (See Eaton 1942). Investigations in this field have been intermittent and progress was slow for many years. About 1944 the need for rapid coverage of large areas with few men created an increased interest in aerial surveys. In the years since then numerous types of airplanes have been used for surveys of a considerable variety of forest insect damage.

By 1947 it was evident that aerial surveys should be evaluated and an attempt made to standardize existing procedures and develop new ones. Accordingly a study was undertaken along three main lines: (1) aerial sketch mapping, (2) aerial photography, and (3) aerial strip counts. Airplane operations during 1947 and 1948 on these three phases of the study are discussed in the following sections. The detailed findings will be reported in separate reports.

AERIAL SKETCH MAPPING, 1947 - 1948

Background

Aerial sketch mapping is a rapid, relatively easy, and reasonably accurate method of delineating insect outbreaks. This method is particularly useful for plotting outbreaks of defoliators but can also be used for those bark beetles that kill timber in mass. The problems are largely those of refining existing techniques, obtaining suitable airplanes, training observers, and scheduling surveys in accordance with the habits of the insects and the characteristics of the attacked timber.

In 1947 extensive outbreaks of the spruce budworm, Archips fumiferana (Clem.) and the Douglas-fir tussock moth, Hemerocampa pseudotsugata (McD) in the Blue Mountains of Oregon provided an excellent opportunity for a large-scale practical test of the aerial sketch mapping method. In 1948 the spruce budworm outbreak increased in size thus giving an even greater opportunity to test the method.

Area Surveyed

The aerial survey of 1947 covered 7,755,000 acres in the Blue Mountains of eastern Oregon and Washington. Approximately 710,000 acres of spruce budworm damage and 70,620 acres of tussock moth damage were detected (See Buckhorn 1). Some 150,000 acres in Pacific and Grays Harbor

Counties, Washington, were covered from the air without detecting any current insect outbreaks.

In 1948 a more intensive survey of 6,898,000 timbered acres in the Blue Mountains revealed 1,243,000 acres of spruce budworm infestation and 15,000 acres of tussock moth infestation (See Furniss, Buckhorn, Wright 3). The aerial survey of 1948 was extended to the Oregon Cascades. On the east side of the Mt. Hood National Forest 401,000 acres were covered, of which 103,000 acres were found to be infested with spruce budworm. Some 3,751,000 acres extending from the western slopes of the Mt. Hood National Forest to the vicinity of Oakridge, Oregon, were observed from a U. S. Forest Service Stinson Voyager. Oregon State Forestry Department personnel inspected 714,000 acres of State lands from a Stinson Voyager 150 contracted for the survey. Approximately 100,000 acres of spruce budworm damage were found and mapped.

Other aerial survey activities in 1948 included the coverage of 75,000 acres on the Tongass National Forest, Alaska, to determine the damage caused by the Sitka spruce beetle and hemlock sawfly. Some 25,000 acres on and adjacent to the Mt. Baker National Forest were examined to evaluate a bark beetle outbreak in Pacific silver fir (Abies amabilis).

Aircraft Used for Aerial Surveys, 1947-48

Five different kinds of aircraft were used at various times during the 1947-48 surveys. The N3N-3 (NC 45036) was flown for the greater part of the work during both seasons although the plane is not the most desirable for aerial surveys. This two-place open-cockpit biplane (235 hp. Wright) flew 24:45 hours during the Blue Mountain Survey in 1947 and 38:05 hours of the 1948 surveys. W. J. Buckhorn sketch mapped the defoliated areas from the front cockpit.

The U. S. Forest Service cooperated with the Forest Insect Laboratory by flying 17 hours of the 1947 Blue Mountain survey in its Stinson Voyager 150. L. J. Sohler, Forest Service pilot, flew the Stinson while Buckhorn and Wear observed. This 4-place high-wing monoplane (150 hp Franklin) is superior to the N3N-3 for aerial survey in several respects. Visibility downward is not impaired by a lower wing; flight performance is good; and a cabin type plane permits easy manipulation of maps and equipment without heavy flying clothes, excessive wind, and exhaust fumes. The western slopes of the Oregon Cascades in 1948 were surveyed in part by W. J. Buckhorn, K. H. Wright, and the writer in approximately 22 flying hours using the Forest Service Stinson.

In addition to the 38:05 flying hours in the N3N-3 on the 1948 Blue Mountain survey six hours were flown in an AT-19 Stinson Reliant 5-place cabin plane. This high gull-wing monoplane (300 hp. Lycoming with constant speed propellor) handled smoothly in rough air, climbed to 13,000 feet at 500 feet per minute, and gave the best performance at high elevations of any plane used for aerial surveys.

On a supplementary survey in Pacific County, Washington, October 1947, R. L. Furniss observed hemlock looper, Lambdina fiscellaria (Guen.) from a Forest Service L-5 liaison plane. This two-place high-wing plane (165 hp. Continental) has excellent visibility on both sides and good performance at elevations below 4500 feet. Space for operating aerial equipment is limited, however.

The 1948 Alaska survey was observed by R. L. Furniss from a two-place Aeronca equipped with pontoons. This 65 hp. high-wing monoplane is not suited to survey since it is underpowered, pontoons obstruct lateral view, and it has limited operating space.

Through cooperation with the Puget Sound Pulp and Timber Company a privately-owned Stinson Voyager was used on the Mt. Baker survey.

Changes in N3N-3

Before the N3N-3 could be used for the 1947 aerial survey all front cockpit and external spray equipment were removed. To increase the space in the front cockpit further and reduce interference with flight controls, rudder pedals and stick mount were removed. The stick mount in the rear cockpit was anchored to the lateral floor brace to which the front seat was attached. The rudder cables were rerouted in the rear cockpit to maintain the necessary rudder control.

Propeller pitch was increased from 11 degrees to 12 degrees to give an added margin of power at high altitudes. Maximum power was obtained at 2150 r.p.m. and full throttle.

Operational Methods and Procedures

Maps - To facilitate sketch mapping in the air, particularly in an open cockpit plane, $\frac{1}{4}$-inch to the mile scale maps are secured to 14-inch by 16-inch aluminum sheets. For extensive aerial reconnaissance this size permits easy handling, and the scale provides adequate mapping area at flying speeds. For intensive surveys, maps of a larger scale are necessary. Predetermined flight lines are drawn on the maps so that the area is covered. Flight lines are spaced for average visibility distance. Two types of flight lines may be drawn depending upon the type of terrain to be surveyed. On rolling low altitude areas and foothills a grid system of flight lines along cardinal directions should be laid out with sufficient sidelap visibility to prevent missing any areas of infestation. At high elevations over long and deeply dissected ridges contour flight strips should be drawn to permit observation of all canyons and ridges.

Safety Precautions

Before every flight weather conditions were carefully checked. A flight plan was filed with C.A.A. whenever possible. If this could not be done, either airport personnel or the Forest Service office in the area would be notified of the operation area for that day. An emergency first aid kit, field rations, matches, and a small axe were kept in the plane in case of a forced landing.

Flight Altitudes - Flight altitudes depended entirely on the elevation of the immediate terrain and visibility. With bright sunlight, few scattered clouds, and no haze the flying was performed 800 feet to 1000 feet above the terrain. Thin overcast skies and haze necessitated flying at 500 feet to 700 feet. Complete overcast or dense haze required flying below 500 feet which was neither safe nor practical from the survey standpoint. Poor visibility frequently obscured light infestations and any aerial survey attempts on bad days were useless.

Airspeeds - Survey airspeeds depend upon the cruising speed of the airplane and the experience of the observer. The six hours of the 1948 Blue Mountain survey flown from the AT-19 Stinson Reliant were at airspeeds ranging from 90 m.p.h. to 120 m.p.h. W. J. Buckhorn, an experienced observer, felt that any speeds beyond 120 m.p.h. would be too fast for accurate sketch mapping. Average airspeeds for survey should range from 75 m.p.h. to 90 m.p.h. As a general rule, the more intensive the survey, the slower the flight should be.

Time of Flights - The scheduling of aerial surveys is an important factor in the accurate delineation of insect outbreaks. Dying needles fall off rapidly after the peak of defoliation and increase the difficulties of detection. Therefore aerial surveys should be made at the time when the discolored foliage of the affected trees is most conspicuous. This differs with the insect. Aerial surveys for the detection of spruce budworm damage should begin in eastern Oregon and Washington by the middle of July and for tussock moth in early June. Heavy defoliation can still be detected up to the first of September but light defoliation is missed. Hemlock looper surveys in Oregon and Washington should begin in early September. Bark beetle surveys present a special problem not yet solved.

Aerial survey flights during the past two seasons could not begin until about 9 a.m. since both east and west slopes of mountain ridges are not fully illuminated earlier in the morning. On level to gently rolling terrain survey flights can be made a little earlier. Infestations are best observed in bright sunlight. Air turbulence and downdrafts increase over level or rough terrain from noon until about 2 p.m., decreasing about 3 p.m. Afternoon flights could be made between 3 p.m. and 5 p.m., as long as east slopes did not fall into shadow.

N3N-3 Performance and Limitations for Aerial Surveys

The open cockpit N3N-3 biplane powered by a 235 hp. Wright engine is unsuited for aerial survey at elevations above 3500 feet under the survey conditions encountered in the mountainous terrain of Oregon and Washington. Several times during the 1947 and 1948 surveys the lack of power in the N3N-3 resulted in hazardous flying. In flying 500 feet to 1,000 feet above the tree tops and in rough terrain there are few places and insufficient time in which a plane can make a forced landing without endangering both plane and personnel. Although most downdraft areas are anticipated by the pilot and are carefully avoided or circumvented, occasionally downdrafts occur which require extra power to recover from their effects.

FIGURE 1. Lower wing of N3N-3 interferes with lateral and forward visibility in aerial survey.

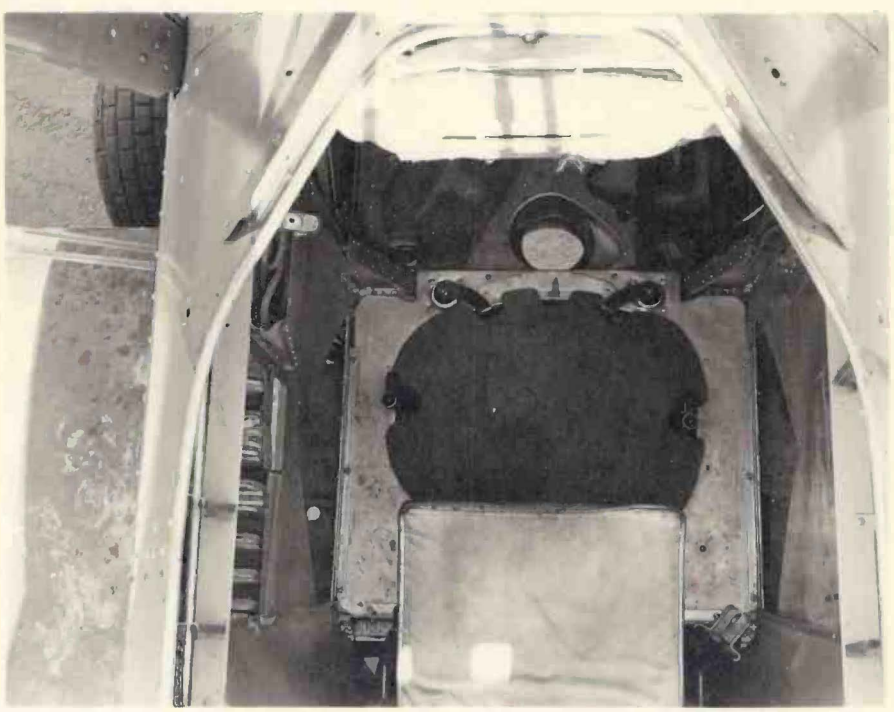


FIGURE 2. Front cockpit ready for aerial survey. Plywood cover over camera hatch. Chest-type parachute in place.

At elevations above 4,000 feet with full power the N3N-3 will not exceed 75 m.p.h. which is insufficient airspeed and power to pull out of a moderate downdraft or climb to desired altitudes. During the 1947 survey over the precipitous Snake River area (6,500 feet) a bad downdraft staggered the N3N-3 causing it to lose several hundred feet in a matter of seconds. The presence of a convenient lateral canyon provided an avenue through which the plane could regain altitude and prevented a very likely crackup. Three times during the 1948 Blue Mountain survey it was necessary to retreat from areas to be inspected, spend twenty minutes climbing to a safer altitude, and view the area from another approach. The Snake River area was safely surveyed in 1948 in a 5-place Stinson Reliant (300 hp.).

Lateral visibility is bad and forward visibility is poor in the N3N-3 due to the obstruction of the lower wing (FIGURE 1). Space and ease of operating aerial equipment and handling maps are limited by the narrow open cockpit. (FIGURE 2). Engine exhaust fumes only add to the discomfort.

Recommendations

It is believed that aerial surveys are the fastest, cheapest, and most effective means by which an appraisal of losses by defoliation over a large area may be obtained. This opinion is based upon two seasons of successful operations. In addition to securing the basic information, aerial surveys simplify ground checking by directing personnel to infested areas without loss of time and effort. Since the infested areas are outlined from aerial spotting, actual time spent in ground checking is limited to the identification of the defoliator and checking suspicious areas of light defoliation not clearly visible from the air.

Aerial surveys demand an efficient plane and a good observer. The airplane should have good lateral and forward visibility, space for handling aerial equipment, and sufficient power to operate at high altitudes. There are several four or five-place cabin type high-wing monoplanes which can be used effectively for aerial surveys of forest areas. (See Wear 7). The observer should be familiar with the area being surveyed both from the air and on the ground. Accurate sketch mapping requires experienced observers. Inexperienced observers should be indoctrinated by flying over known insect infestations and over the timber types and terrain to be encountered in the actual survey.

AERIAL PHOTOGRAPHY, 1947-48

Preparation of N3N-3 for Aerial Photography

The N3N-3 was converted for aerial photography at the Forest Service airbase shop at the Portland Airport in September 1947. Many changes had to be made in the front cockpit to accommodate the photographer, vertical mapping K-17 camera, and the vertical view finder.

The rudder controls and stick mount had been removed before the aerial survey began. More space was provided for photography by the installation of a small 8" x 14" jump seat in place of the standard bucket seat. (FIGURE 3). To simplify the cameraman's operations a chest type parachute was placed in the space occupied by the front cockpit instrument panel.

FIGURE 3. Photographer observing terrain through view finder

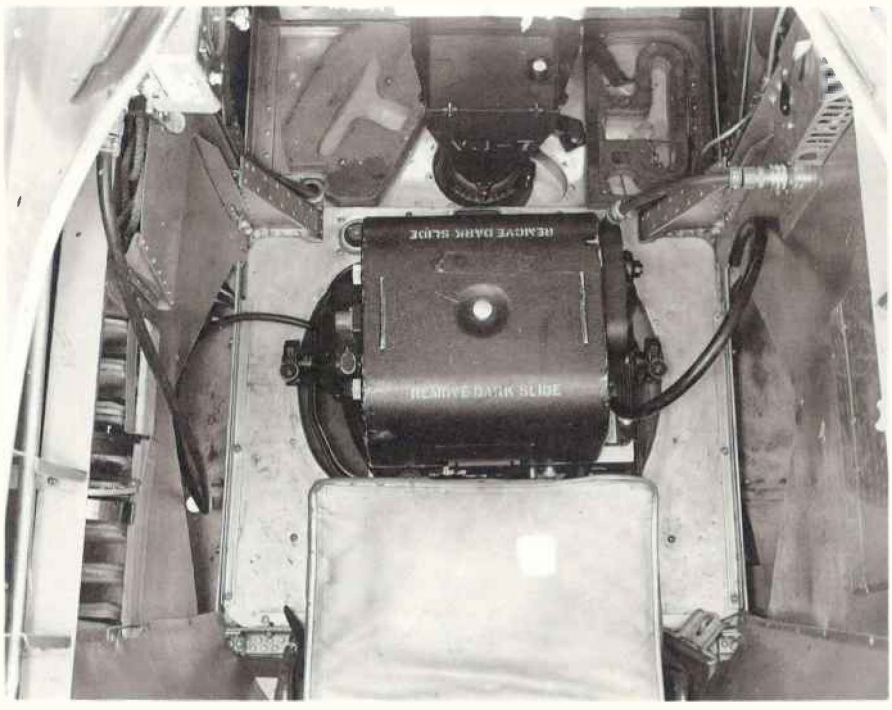


FIGURE 4. Camera in mount, jump seat in operating position. Intervalometer on left with cable to camera, power cable to camera on right. Vertical view finder ahead of camera.

Due to the large space occupied by the K-17 camera and the camera mount additional lateral space had to be provided in order that the photographer could have foot room. Small partition braces were cut away for foot space below on each side of the floor. The K-17 camera was operated manually in 1947 by hand cranking from beneath the seat and under the right leg. This very difficult and awkward operation was simplified in the 1948 operations by the installation of a 24 volt electrical system for automatic operation, except for leveling. The leveling bubble on the left side of the camera was illuminated by a flashlight attached to the bottom of the jump seat.

The capacity of the 46-gallon gasoline tank was increased to 63 gallons to increase the length of time in the air and to provide extra gas necessary to climb to photographic altitudes. The service ceiling of the N3N-3 fully loaded is 8,400 feet above sea level. The shape of the original tank was changed so that the photographer could get his head into position to observe the passing terrain through the vertical view finder. (FIGURE 5). The lower half of the round tank was cut off and a rectangular section 14" x 26" x 24" was welded to the upper half. A $\frac{1}{2}$-inch sheet of foam rubber was glued to the back of the L-shaped tank as a buffer for the photographer's head when observing through the view finder.

An aluminum bulkhead was inserted behind the front seat brackets in order to prevent any possible interference with rear cockpit rudder controls by the photographer while he is operating the camera. A side panel was installed on the left side of the front cockpit to cover engine controls forward. For convenience in changing filters on the K-17 camera, a box with partitions for camera filters was mounted on the left bulkhead and an accessories box provided on the right bulkhead. Two plywood camera magazine mounts were bolted to the floor on either side of the view finder - one to hold an extra film magazine; the other to facilitate changing magazines in the air. (FIGURE 4). A plywood cover was made for the camera hole for use while filters were being changed and to remain in place when the camera was out as shown in FIGURE 2. Lack of time and funds made it impossible to install a much-needed hatch cover to protect the camera lens during take-offs and landings.

Scope of the Photography

The N3N-3 was equipped for aerial photography in the fall of 1947, and one series of photographic tests was completed in October. This series consisted of flying, preparing, and interpreting vertical photographs taken with a K-17 aerial camera to delineate trees killed by bark beetles on the Squaw Ridge area of the Sisters Ranger District of the Deschutes National Forest. Three altitudes and three different filter combinations were used in photographing a marked 320-acre plot. Further photographic experiments were flown in May and July 1948 on the Warm Springs Indian Reservation.

In 1948 on the 4,500-acre Heppner spruce budworm project, color photographs of tree markers and areas defoliated by spruce budworm were taken with an aerial K-20 camera. Aircraft on spray runs were also obliquely photographed in black and white from the N3N-3.

FIGURE 5. Changing filter on K-17 camera with special adapter.

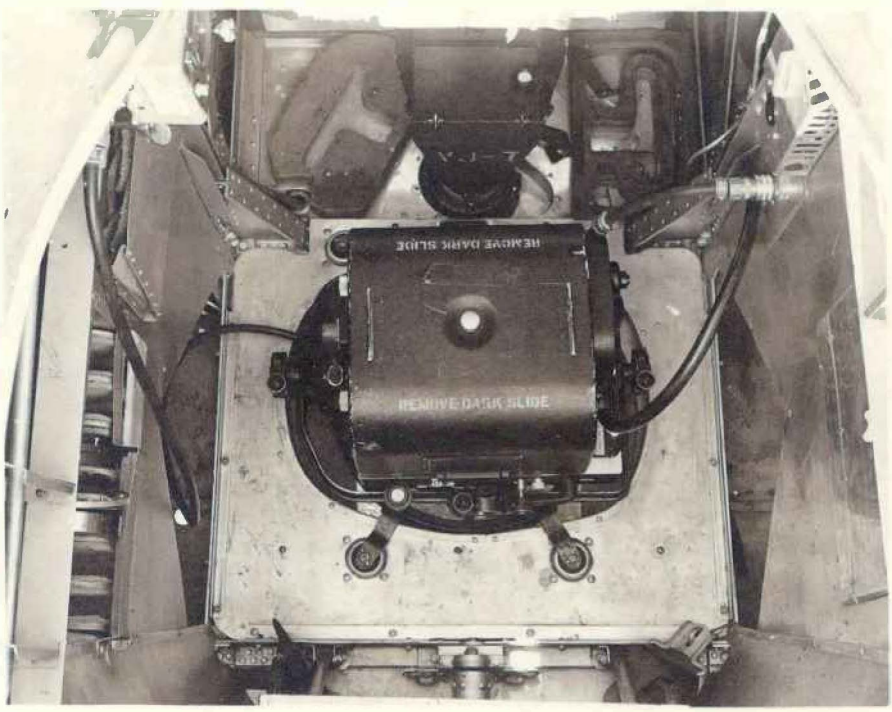


FIGURE 6. Seat raised in front cockpit to show control stick torque tube attached to horizontal floor member. Venturi tube connection to K-17 camera on right side. Magazine mounts on either side of vertical view finder.

In cooperation with Truck Crop Insect Investigations, Walla Walla, Washington, 100 square miles of alfalfa fields and farmlands were vertically photographed in July with a K-17 aerial camera. The resulting photographs are to be assembled into a mosaic for the purpose of locating alfalfa fields, the over-wintering area of the pea aphid. Moving pictures and still shots in color of Truck Crop Insects N2S-5 Stearman spraying a pea field near Walla Walla were taken from the N3N-3 during the same period. The plane and its spray pattern were also photographed at different angles from above and below.

The final aerial photography in 1948 with the N3N-3 was for the Division of Surveys and Maps, U. S. Forest Service, Region 6. A triangulation point and a twenty-five mile logging road on the Ochoco National Forest were vertically photographed with a K-17 camera in August.

Air and Ground Procedures

Vertical Photography with a K-17 Camera - All vertical photographs taken from the N3N-3 were made with a K-17 6-inch focal length aerial camera and equipment loaned to the Portland Forest Insect Laboratory by the U. S. Naval Air Station, Seattle, Washington. The photographic equipment included the camera, extra magazine, filters, gimble type camera mount, an A-2 10-inch vertical view finder for observing drift and terrain passing beneath the plane, and a B-3B intervalometer with electrical cables.

Preflight preparations included (1) determining scale of photography and flight altitudes to obtain the desired scale, (2) determining width and extent of flight line for adequate coverage and sidelap, (3) drawing flight lines on a good base map and marking check points visible from the air, (4) loading magazines in the darkroom with the amount of film necessary to take the total photographs based on length of flight lines, interval between photographs, and number of flight lines, (5) checking the electrical operation of the photographic equipment before taking to the air, (6) checking weather conditions and (7) filing flight plans with the C.A.A. or Forest Service office.

Where experimental photography was required, ground plots were selected and outlined on the map, marked at the corners on the ground, and the different film, filters, and scales determined.

Good weather conditions are essential to good aerial photography. Bright sunlight, few clouds, comparative calm, and little or no haze are required. Even with good weather aerial photography is dependent upon the season of the year and the geographic latitude of the area to be photographed.

At the 45th meridian aerial photography for the detection of insect-attacked trees should be limited to the period of May 15 to September 15. As the length of shadows increases after this period ground detail is blocked out and the difficulties of interpretation increase. The greatest amount of ground detail shows on vertical photographs when the sun's rays are directly overhead. In the Pacific Northwest vertical photographs taken between 11 a.m. and 2 p.m. are the best for stereo-interpretation.

Photographic flight procedures include (1) climbing plane to desired altitude for specific scale of photography (corrections made for effect of temperature on altimeter readings), (2) determining wind and drift in the directions of photo flight runs by using vertical view finder, (3) flying a dry run to align pilot and photographer (set drift correction into the camera), (4) approaching the first photo run for correct orientation, (5) warning photographer when to start camera and when to stop at the end of a photo strip, and (6) recovering from photo run and setting up approach for successive runs. On the actual photo run the photographer keeps the camera level, observes terrain and spots check points on the flight line through the view finder, and notifies the pilot of any change in drift. A drift change is compensated by the pilot by increasing or decreasing crab of the airplane with a flat skid. The photographer sets any new drift into the camera. Records are kept of flight strips, direction of flight, time photography commences and stops, number of exposures on each strip, and camera settings. Weather conditions, flight altitudes, and drift on each run are also recorded.

Experimental photography involving film and filter combinations requires the photographer, in addition to his regular procedures, to disconnect and lift the 45 pound camera from its mount, set it upside down on his knees, (FIGURE 5) change filters and replace the K-17 in the mount for the next photo test.

Oblique Photography from N3N-3 - The lower wing, struts, and flying wires obstruct the photographic shooting angle forward (FIGURE 1). Lateral shots can be made between wing tip and tail assembly from either side. Tree markers, ground plots, and other still objects can best be photographed from the N3N-3 by approaching the object at an angle and skidding away when in position to shoot. In photographing a moving object such as a plane, one can either fly on a parallel course above or below, or on an interception course at right angles. The first method presents an easy shot or series from a movie camera. The latter method requires split-second timing with a limited time to shoot. Good oblique photos have been made with K-20, SpeedGraphic, 35 mm., and 16 mm movie camera. The camera should not be subjected to the turbulent air of the slip stream and not touch the side of the plane since vibrations blur the pictures.

Recommendations

TheN3N-3 is not suitable for vertical photography. A short focal length aerial camera must be used since the ceiling of the N3N-3 loaded is limited to 8,400'. This type of camera produces excessive distortion in large-scale photography. The photographer, aerial camera, and other photographic accessories are confined in anoperating space two feet square. The open cockpit and exhaust fumes add to the discomfort. Visibility for alignment on photo runs is poor.

An aerial photographic plane for the scale of our work should have the following: (1) power to climb up to 16,000 foot, (2) at least a 3-foot by 4-foot operating space for photographer and photographic equipment, and (3) good performance and stability in rough air. A high-wing, 4 to 5-place cabin type plane that meets the requirements would be satisfactory.

Three post-war aircraft are qualified for vertical photography of the type needed on forest insect surveys: the 5-place Cessna 190 (240 hp.), or 195 (300 hp.), and the 4-place Luscombe Silvaire (165 hp.). The Cessna 190 or 195 have better performance and stability than the 4-place Luscombe, and they can be factory equipped for aerial photography. Of the pre-war planes the 5-place gull wing Stinson Reliant (300 hp or 450 hp.) meets the desired specifications. These planes would also fit into the aerial survey program. (For detailed performance specifications of these planes see Wear 7).

AERIAL STRIP COUNTS ON FOREST AREAS, 1947 - 48

Introduction

Line strips are used effectively for many phases of ground sampling on forest areas. The aerial application of this method for determining insect loss on forest areas by visually counting insect-killed trees through an opening in the floor of the plane or over the sides of the fuselage has good possibilities. During the 1947 season strip counts were made over the fuselage from a Forest Service Stinson Voyager, and through the camera hatch of the N3N-3 to check the feasibility of this method. One series of strip counts was flown with the N3N-3 in August 1948.

Aircraft Operation

The Stinson Voyager 150 was flown in September 1947 by Forest Service pilot L. J. Sohler on the Ochoco National Forest for the first strip counts. Buckhorn and Wear made alternating counts of red-top trees killed by bark beetles from opposite sides of the plane as it flew a prescribed flight line 500 feet above the tree tops. A 45 degree angle from the vertical was assumed from the observers line of sight as he sat in the plane. An angle of approximately 15 degrees is lost from a point vertically beneath the plane to the observers line of sight over the fuselage of the plane. This leaves an approximate observing arc of 30 degrees or a 330 foot strip (Diagram 1). The flight courses were aligned between geographical land marks over a known distance and relatively level terrain.

A similar flight procedure was followed in October 1947 except that the observer viewed the terrain through the 13½-inch camera opening in the floor of the N3N-3 (FIGURE 8). In order to fly a tally width strip (330 feet) it was necessary to determine the flight altitude above the terrain beforehand. Eye level was set at 32 inches (2.67') above the 13½-inch (1.12') opening. By geometric proportion the height to fly above the terrain was found to be 780 feet. (Diagram 2). From a contour map of the area the flight altitude above sea level was determined for the entire strip. It was necessary to adjust flight altitudes with the general rise or fall of topography to maintain the proper elevation above the ground. Two separate flights were made with W. J. Buckhorn and J. M. Whiteside counting red tops. The writer flew as close as possible the same altitude and flight course for each observer.

Incorrect

tangent $\angle$ = side opposite / side adjacent

tan 15° = .26795

$.26795 = \frac{x}{500}$

$x = (.26795)500$

$x = 133.975$ ft

500 − 133.9' = 366.1

Strip observed = 366.1 ft.

Diagram 1

Stinson Voyager

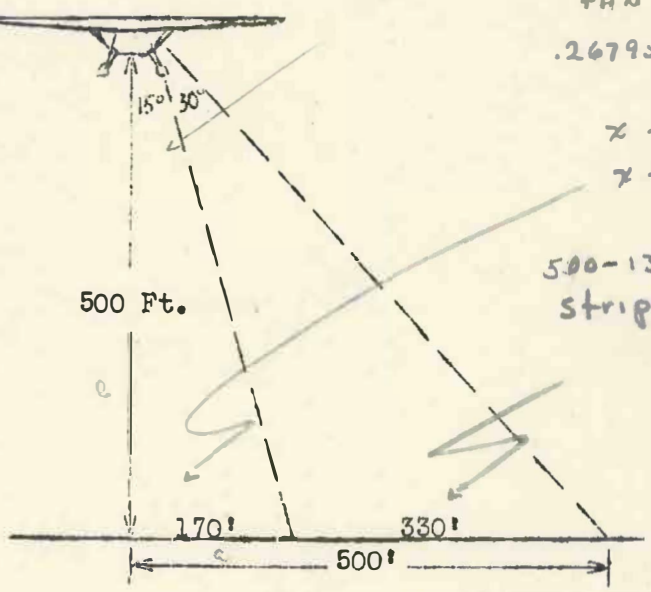
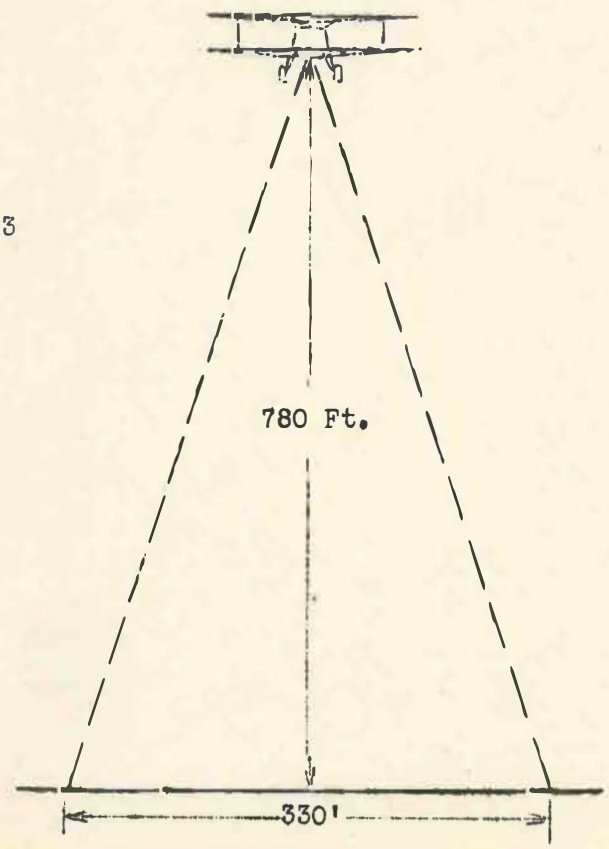


Diagram 2

N3N-3



Eye level 32" (2.67')
Hole width 13½" (1.12')
Altitude above ground is 780'

$\frac{112'}{330'} = \frac{2.67'}{X} \quad X = 780'$

Eye level 40" (3.33')
Hole width 13½" (112')
Altitude above ground is 980'

$\frac{112'}{330'} = \frac{3.33'}{X} \quad = \frac{980'}{}$

In 1948 three flight strips totaling 42 miles were marked on a contour map of the Warm Springs Indian Reservation. These strips were almost identical to those flown the previous year. A ground strip 2½-chains each side of the flight line was cruised by a three-man Forest Service crew for a tally of trees killed in 1946, 1947 and 1948 that would be visible from the air. These trees were mapped and pertinent data usually recorded by spotters on ground cruises were taken for each tree. White crosses of casting plaster spread lightly on the ground marked the intersection of the flight line and roads. This provided a check against the aerial counts made by Buckhorn and Whiteside from the N3N-3 during the same period. For greater ease in observing terrain passing beneath the N3N-3 the eye base level was extended from 32 inches to 40 inches. This necessitated an increase of the observation elevation above ground from 780 feet to 980 feet. (See Diagram 2). Poor photography weather and lack of time prevented the taking of aerial photographs on the three strips visually cruised in August 1948.

On all flight strips the same procedure of tallying was used. Since the indicated airspeed of the airplane and the distance of each flight strip were known, the interval in seconds required to fly a mile of the strip could be computed. This interval was maintained the length of the strip. The pilot notified the observer at the end of each mile and the trees spotted in that mile were recorded. If the actual ground distance and airspeed distance did not correspond, adjustments were made in the tally over each mile of the strip. The following example illustrates this adjustment.

A five mile strip on the ground due to strong tail winds indicates an apparent airspeed distance of only four miles. In this case the trees are redistributed as follows:

Airspeed Distance			Ground Distance		
	No. Trees			No. Trees	
No. Miles	Per Mile	Cumulative	No. Miles	Per Mile	Cumulative
1	15	15	1	12	12
2	12	27	2	9.6	21.6
3	25	52	3	19.9	41.5
4	18	70	4	14.5	56
			5	14	70

A more detailed report of these strip counts will be prepared at a later date.

Recommendations

There are certain features of the aerial reconnaissance strip counts which are important in evaluating insect losses of forest areas provided the method proves sufficiently accurate. After an aerial strip count is made the loss figures are immediately available and can be applied on an area basis. Counts can be made through openings in the floor or by any other means which will restrict the tally to a strip of designated width. Certain weather conditions unsuitable for photography are good for strip counts. An aerial photographic sampling method requires

excellent weather for taking pictures, plus extra time for processing film and printing pictures, and time for interpreting and evaluating the loss on an area basis. Considerable time would be saved by the aerial reconnaissance strip method.

There are two flying difficulties which will materially offset the accuracy of the reconnaissance strip counts. Seldom will a predetermined flight strip fall on level ground throughout. The only means by which an accurate altitude above the terrain can be determined and maintained is by experience and the use of a radio altimeter. It is suggested that this sensitive instrument be installed in a plane used for this type of sampling. A second difficulty is in flying the plane level in turbulent air at low altitude. Rough air causes the plane to roll and expose more terrain to view through the opening in the floor than is required for proper sampling. To improve this situation it is advisable to fly at the maximum altitude at which an accurate count of red-top trees can be made. Air turbulence usually decreases at higher altitudes. The viewing aperture at higher altitudes would be smaller for the same 330 foot strip width viewed at 980 feet.

COMMUNICATIONS, 1948

Prior to 1948 intercommunication between ground personnel and the airplane during spraying, survey, and photographic activities was limited to pre-arranged hand signals or ground indicators. Forest Service and war surplus radio equipment was either too heavy to carry in the plane or not tunable to our assigned frequency, 40.3 mc. The 1948 field season saw the introduction of a light weight one channel radio developed by the Engineering Department of the Oregon State Board of Forestry, and commercially produced in Portland, Oregon.

The five pound FP Radiophone with normal frequency range from 30 mc. to 40 mc. (possible extension to 50 mc.) was primarily designed for intercommunication between lookout stations and fire fighting crews. However, the FP "peanut" has been used satisfactorily in planes for distances ranging from five to fifty miles, and for ground use from one to 100 miles depending upon topography. The FP Radiophone is activated by small A and B dry batteries. Where the aircraft has not been shielded ignition noises interfere with reception in the plane but ground transmission is readable. This difficulty is partially overcome by use of a more powerful transmitting unit on the ground.

On the 1948, 4500-acre Heppner spruce budworm experimental project two FP Radiophones were used, one at the weather station on the spray area (FIGURE 7), the other at the airport. A larger FX type radio was used at the airport when the FP set was needed in the plane.

Plans to flight test another light weight radio (KT type) developed by the Oregon State Board of Forestry did not materialize. This KT type radio was designed for car use on 6 volts but it has been used successfully in airplanes and can be manufactured for either 12 volt or 24 volt systems. The ten pound unit uses either vertical or horizontal antennae with a 50-mile range from 2,000 feet or 7 to 10 miles at 500 feet. Normal frequency is 30 mc. to 40 mc.

FIGURE 7. FP Radiophone used in communicating with airfield from weather station on spray plot.

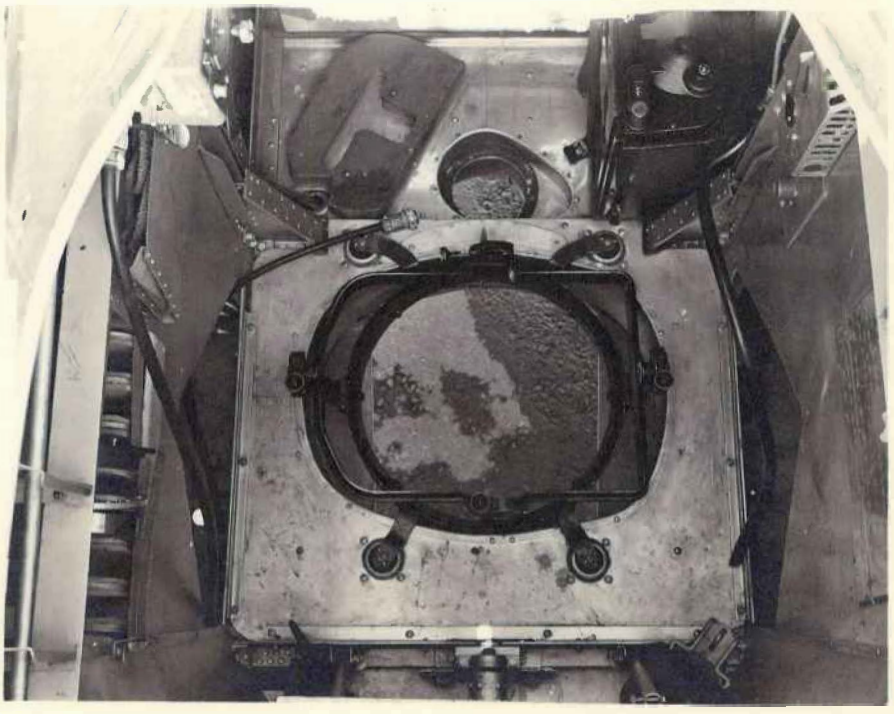


FIGURE 8. Camera hatch open for aerial strip counts. Camera mount in place. Extra magazine in right holder.

Since the FP and KT type radios have only one frequency, another radio would be needed for normal airplane transmission to control towers and listening to radio ranges. Most open cockpit biplanes do not need radio since they operate from small fields which do not have radio control towers and are limited to contact flight regulations. For cross country and extended flights in the Northwest it is desirable to have at least a radio range receiver and a radio tunable to the U. S. Forest Service and State Forestry Department frequencies.

AIRCRAFT MAINTENANCE AND COSTS, 1947-48

The U. S. Forest Service cooperated with the Bureau of Entomology and Plant Quarantine in providing hangering and maintenance facilities for the N3N-3 at the Portland Columbia Airport. 100-hour checks, installation of new parts and equipment, and general aircraft maintenance were made under the supervision of the Forest Service mechanic with C.A.A. approved A. & E. license.

One maintenance difficulty is securing repair parts for the N3N-3. The Naval Aircraft Factory in building the N3N-3 jobbed out the various parts that went into the plane. The companies manufacturing these parts during the war have discontinued production and there are no surpluses available. Parts have been salvaged from wrecked planes, substituted where possible, and others hand-made with the worn part for a pattern.

Normal operational and maintenance costs (Table 1) during 1947 and 1948 have been tabulated to exclude the additional costs necessary to: (1) refabric the entire plane, (2) prepare the N3N-3 for aerial survey and aerial photography, (3) install the 24 volt electrical system including starter, generator, and outlets for electrically heated flying suits and automatic camera operation and (4) purchase a 300 hp. Lycoming engine with constant speed propellor to replace the 235 hp. Wright engine. Average hourly operating cost during this period was $7.08 per hour. Table 2 shows the special costs for the N3N-3. A summary of the operation costs for the different kinds of aircraft used by the Portland Laboratory is provided in Table 3.

Table 1.

Summary of Normal Operational and Maintenance Costs for N3N-3:

Expense Items	1947 May 1 - Dec. 31	1948 Jan. 1 - Dec. 31	Total
Gas and Oil	$496.33	$516.26	$1,011.59
General maintenance	78.53	127.79	206.32
50 and 100 hour checks	192.98	139.20	332.18
Parachute maintenance	8.50	35.55	44.05
Incidental hangering	14.25	27.00	41.25
Aviation supplies and charts	46.18	--	46.18
	$835.77	$845.80	$1,681.57
Flying time:	117:25 hrs.	120:25 hrs.	237:50 hrs.
Average hourly operating cost:			$7.08

Table 2.

Summary of Special Costs for N3N-3

Expense Items	1947	1948	Total
Survey preparation	$ 95.45		$ 95.45
Aerial photography	366.00	$ 78.00	444.00
Purchase of 300-Lycoming engine & propellor		450.00	450.00
Gas tank remodel		90.00	90.00
Electrical installation		385.89	385.89
Refabricing operation			
Disassembly		75.00	75.00
Refabric and repair		1,978.70	1,978.70
Assembly and relicensing		365.95	365.95
	$461.45	$3,423.54	$3,884.99

Table 3.

Summary of Costs for Other Aircraft, 1947 and 1948

Airplane	Nature of Operation	Flying Hrs.	Year	Cost	
L-5 (F.S.)	Survey - Pacific Co., Wash.	2:55	1947	$ 29.16	
Stinson Voyager (F.S.)	Survey - Blue Mts., Ore.	17:00	1947	258.26	
Stinson Reliant	Survey - Blue Mts., Ore.	6:00	1948	29.43	
Stinson Voyager (F.S.)	Survey - Oregon Cascades	14:15	1948	142.50	*
Stinson Voyager	Survey - Oregon Cascades	9:15	1948	92.50	*
" "	Survey - Mt. Baker N. F.	2:00	1948	40.00	*
Aeronca Champion	Survey - Tongass N. F.	4:10	1948	85.00	*
N2S-5	Purchase price	--	1948	700.00	
N2S-5	Ferry, Georgia to Oregon	37:55	1948	400.00	*
		Total		$1,776.85	

*Costs paid by cooperators.

OPERATIONAL CONCLUSIONS

Based upon two seasons of flight activities involving aerial spraying, aerial survey, reconnaissance strip counts, and aerial photography in the N3N-3 it is the writer's opinion that except for aerial spraying (provided a 300 hp. or an even more powerful engine is installed) this biplane is not suited to any of the aerial activities carried on by the Portland Forest Insect Laboratory. The general characteristics of the plane are a hindrance to our aerial work. Visibility downward and forward is partially blocked by the lower wing and operating space is cramped into one-half the minimum for efficient work. Other disadvantages of an open cockpit plane are obvious.

There are several post-war planes and one pre-war high-wing plane which would be excellent for the aerial survey, reconnaissance, and photographic programs conducted by this laboratory. Preliminary flight tests have been made in the different aircraft and a detailed report submitted with recommendations. (Wear 7). The recommendations are based upon the essential requirements; (1) excellent performance in operating at high altitudes in rough mountainous terrain, (2) good forward and lateral visibility, and (3) adequate space for operating aerial equipment. Briefly, the all-metal constructed post-war 5-place Cessna 195 (300 hp. Jacobs), 5-place Cessna 190 (240 hp. Continental), and 4-place Luscombe Silvaire (165 hp. Continental) fulfill the flight requirements for our work. The fabric-over-metal constructed Stinson Reliant (300 hp. Lycoming or 450 hp. Pratt and Whitney) represents the only satisfactory pre-war aircraft suitable for all phases of our program.

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